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Prices and social behavior: Evidence from adult smoking in Canadian Aboriginal communities

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Abstract

This paper provides estimates of tobacco price elasticity explicitly distinguishing between two price effects: the direct effect, reflecting individual reaction to a price change, and the indirect effect, whereby price influences the individual by changing community smoking behavior. Canada's Aboriginal communities are small and secluded, allowing for plausible identification of reference groups on a relatively large scale. Estimates suggest a 10 percent increase in price decreases daily smoking by 0.91 percentage points (2.11 percent), occasional smoking by 1.24 percentage points (8.27 percent) and average smoking intensity by 0.15 cigarettes per day (2.9 percent). It is found that the indirect effect almost doubles the response to a change in tobacco prices over the direct effect alone.

JEL codes: D12, I10, I38

Keywords: social interactions, price elasticity, Aboriginal Canadians, smoking, tobacco tax

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1 Introduction

Behavioral intervention is often used to achieve a desired population outcome: subsidies to encourage education; sexual awareness campaigns to avert teen pregnancy; information campaigns and taxation to improve health. Given the prevalence of these interventions, it is important that we understand the channels through which they influence behavior. Social interactions may be an important channel. Consider the effect of a tobacco tax to discourage smoking. When social interactions are endogenous—in the sense that an individual's smoking is positively influenced by the smoking of others—an increase in the price of tobacco will influence individual smoking through two channels: directly, by making smoking relatively more expensive, and indirectly, by decreasing community smoking rates and therefore decreasing the marginal utility of smoking. These endogenous social interactions have broad policy implications. For example, they imply an important aggregation problem: when only the direct effect is known, we cannot determine the effect of a population intervention by aggregating individual behavior. Further, endogenous social interactions imply that intervention effectiveness can be improved through designs that take advantage of social interactions rather than focus only on individual decisions.

In this paper I estimate the effect of price on adult smoking explicitly accounting for the potential influence of community smoking rates on individual smoking behavior. Separate estimates are provided for the direct and the total effect of a price change on adult smoking, with the difference being the indirect effect. Previous studies attempting to estimate endogenous social influences on a large scale have been limited in their ability to identify a plausible reference group and control for endogenous neighbourhood selection (see Evans *et al.* 1992). In this respect Canada's Aboriginal communities provide a unique context. Small populations and tight knit communities mean that individuals are likely to be aware of the conspicuous activities, such as smoking, of their fellow community members. This "reference group" assumption is a critical component to incorporating social interactions into estimation (see Manski, 1993, 2000). Community selection can be treated as exogenously determined through birth or marriage, and barriers to moving into the communities and incentives to remain in the communities result in low mobility. Further, changes in policies exempting Aboriginals from provincial sales tax provide a source of large and exogenous variation in tobacco prices.

The empirical strategy exploits a repeated cross section of 95 communities and 17,720 individuals created from the 1991 and 2001 waves of the Aboriginal Peoples Survey, a post-census survey administered by Statistics Canada. This provides a rich community-level panel structure to control for unobservables, such as variation in preferences across communities arising from differences in historical and spiritual attachment to tobacco. Changes to provincial policies regarding tax exemptions in Aboriginal communities provide exogenous variation in tobacco prices. This study provides the first unified documentation of these policies and the resulting between-period price changes (in constant dollars) are as large as 40 percent.

Several important contributions are made to the existing literature. First, I provide separate estimates of the direct and the total effect of a tobacco tax on adult smoking. For daily smoking the estimated direct effect of a price increase is approximately half the total effect, suggesting that endogenous social interactions significantly influence the observed behavioral response to a price change. Relatively few studies consider how estimated price elasticity is affected by endogenous social interactions. Of those that do, Sen and Wirjanto (2009) find that social interactions do not significantly impact elasticity estimates, while Auld (2005) and Powell *et al.* (2009) find that excluding controls for social interactions from the regression leads to a larger estimate of the price elasticity. While this latter finding is consistent with social interactions having a multiplier effect on price elasticities, a shortcoming of these studies is that the direct price elasticity (estimated by controlling for reference group smoking) is compared to an elasticity estimated from a potentially misspecified model and it is not clear that the total price effect on smoking behavior is accurately estimated. I explicitly account the direct and indirect effects to provide an identified estimate of total price elasticity.

Second, I estimate the effect of endogenous social interactions for adults at the community level. I find they are important. A 10 percentage point increase in community smoking rates increases the probability a given individual smokes by 4.7 percentage points. A 10 percentage point increase in daily smokers increases the probability a given individual smokes daily by 7.9 percentage points. This builds on previous studies that examine how youth smoking is impacted by peer smoking in the same school or classroom (for example see Powell *et al.* (2005), Krauth (2007), Soetevent and Kooreman (2007), and Fletcher (2010).) This research has resulted in a range of estimated endogenous effects for youth, but it is unclear whether these peer effects carry over to the behavior of adults. Cutler and Glaeser (2007) find that the probability an adult smokes increases 40 percent if their spouse smokes. When they expand their peer group to individuals in the same metropolitan area, age cohort, and education level there is no significant group effect. These results may suggest that peers are important to youth but not adult smoking. Because Aboriginal communities are small and secluded I am able to identify a feasible reference group for each individual that is larger than the household or classroom, but smaller than a metropolitan area. My findings suggest that the importance of social interactions on behavior does not go away, or even diminish, in adulthood, nor do they weaken in groups of almost 1,000.

Third, I provide the first estimates of tobacco price elasticity for Canada's Aboriginal communities. For adults, a 10 percent increase in price is estimated to lead to a 0.91 percentage point (2.1 percent over 2001) decrease in daily smoking, a 1.24 percentage point (8.3 percent over 2001) decrease in occasional smoking, and decreases average smoking intensity by 0.15 cigarettes per day (2.9 percent over 2001). This is consistent with a large literature estimating the importance of price in smoking. Typical estimates of price elasticity are between -0.5 and -1.7 for youth initiation (Powell *et al.*, 2009) but substantially lower in adult populations. Franz (2008), for example, estimates an adult price elasticity of -0.19 and Cutler and Glaeser (2007) find price does not significantly affect adult smoking. The estimates provided in this study are important for health policy as the exemption of Aboriginal communities from provincial sales taxes, which make up between 29 and 50 percent of the final price on tobacco, is often cited to explain high Aboriginal smoking rates.

Aboriginal People's Survey data allow me to address several novel issues in the literature. However, these data come with some limitations. Estimation utilizes variation in community aggregates over time. The use of sample analogs in place of the true aggregates and the fact that community aggregates tend to change very slowly means the the fixed effects estimates produce large standard errors and instruments which, by conventional measures, are weak. This is most problematic for occasional smoking where the empirical strategy does not appear to successfully identify the structural equation. Steps are taken to address these issues, such as calculation of weak instrument robust confidence intervals for the endogenous regressors and the inclusion of several sensitively checks. However, these issues highlight the need for reliable data collection, both with respect to the estimation of social effects and with respect to Aboriginal communities in Canada.

The communities examined in this study are First Nations reserves, land that is set aside for exclusive use by registered Indians. "Aboriginal Canadian" refers to three broadly defined groups: First Nations, Métis and Inuit. As this study will focus largely on First Nations, who are the primary residents of reserves, this term will be adopted for the remainder of the paper. However, it should be kept in mind that a small portion of reserve residents claim Métis and Inuit identity (1.15 and 0.05 percent in the data used here). Over one million Canadians claim First Nations identity of which 40 percent are estimated to live on-reserve

(Statistics Canada, 2006). First Nations represent the fastest growing population in Canada, with an estimated growth rate more than five times that of the non-Aboriginal population (Statistics Canada, 2005). Surprisingly, despite often dire economic and health conditions and the existence of remarkably similar communities in the United States, Australia and other countries, these communities have received little attention in the economics literature.

The remainder of the paper proceeds as follows. In Section 2, I introduce a simple model of individual tobacco demand that incorporates tobacco use by others in the community, based on the linear-in-means model of social interactions. This model is used to explicitly show the multiplier effect arising from endogenous social interactions. I then discuss the empirical estimation strategy for the reduced form and structural equations. The reduced form estimates yield price elasticity which reflects the total effect of a price change and structural estimates yield price elasticity which reflects the direct effect of a price change. The structural equation is estimated using community high school graduation rates and a measure of perceived community problems reported by community members to instrument the endogenous community smoking rates. Cross-community variation in the change in these characteristics over time identifies the endogenous structural parameters. This strategy yields precise and robust estimates of structural parameters with respect to daily smoking and smoking intensity. In Section 3, I discuss the data used in the empirical estimation and provide a brief description of the evidence supporting the underlying reference group assumption. The results of the empirical estimation are presented in Section 4 followed by an analysis of the robustness of the estimates in Section 5. Robustness checks include relaxing the assumption of instrument exogeneity following the methods proposed by Conley, Hansen and Rossi (2012). Finally, Section 6 concludes with a brief discussion of the results.

2 A model of tobacco demand

In this study I think about the influence that community smoking has on the smoking decisions of individual community members. There are a number of reasons to think that this is a realistic characterization of behavior. Tobacco use may be an informal mechanism to signal social identity or group membership (Akerlof and Kranton, 2010). Individuals may inform their opinions on the health consequences of smoking based on observed smoking of others. Addicted smokers may increase the quantity of tobacco they consume, or decrease the desire to quit, when surrounded by other smokers. Alternatively, to the extent that smokers are altruistic, non-smokers being offended by tobacco use may provide an incentive for smokers to reduce consumption or initiate efforts to quit. The communities examined here are relatively small in population and have a limited number of locations, such as recreation centers, community halls, or restaurants, for residents to gather outside of the home. For this reason, the tobacco use an individual observes will reflect the mean tobacco use in the community.

With this in mind, individual utility from tobacco use is specified as a function of mean tobacco use in the community. To provide a framework for thinking about how community behavior and prices influence smoking behavior I adopt a quasi-linear utility specification.[1] The utility for individual i is given by:

$$U(C_{igt}, s_{igt}, E_{gt}[s]) = \eta C_{igt} + \left[A_{igt} + \alpha E_{gt}[s] - \frac{1}{2} s_{igt}\right] s_{igt} \tag{1}$$

C_{igt} and s_{igt} are the consumption of a composite commodity and tobacco for individual i in group g at time t. $E_{gt}[s]$ is the mean level of tobacco consumption in community g. The parameter η captures the constant marginal utility from consumption of the composite commodity to individual i. A_{igt} is a function of observable and unobservable determinants of individual smoking behavior. Social interactions are captured by $\alpha E_{gt}[s]$, the marginal utility of s_{igt} attributable to mean smoking rates in the community. Therefore when mean tobacco use in the community increases by one unit, i's marginal utility increases at the constant rate α. Following Manski (1993), α is referred to as the *endogenous social effect*.

Each community consists of a sufficient number of individuals such that no single individual's behavior has a significant influence on $E_{gt}[s]$, and all individuals take $E_{gt}[s]$ as given. Each chooses consumption over s_{igt} and C_{igt} to maximize Eq. (1) subject to their budget constraint, $C_{igt} + P_{gt}s_{igt} \geq Y_{igt}$, where P_{gt} is the real price of tobacco faced by community g at time t, and Y_{igt} is i's real income. Price of the composite commodity is normalized to 1. This results in the following first order condition (focusing on the interior solution):

$$s_{igt} = A_{igt} + \alpha E_{gt}[s] - \eta P_{gt} \tag{2}$$

This condition states that individual i will choose s_{igt} such that the marginal benefit from consuming s_{igt}, $A_{igt} + \alpha E_{gt}[s] - s_{igt}$, is equal to the marginal cost, ηP_{gt}. Notice that ηP_{gt} reflects the utility forgone by consuming P_{gt} fewer units of C for every unit of s.

In equilibrium all individuals choose according to Eq. (2). We can solve for $E_{gt}[s]$ by

[1] This is similar to the utility specification used in Glaeser *et al.* (2003).

taking expectations on both sides of Eq. (2):

$$E_{gt}[s] = \frac{E_{gt}[A]}{(1-\alpha)} - \frac{\eta P_{gt}}{(1-\alpha)},$$

and substituting back into Eq. (2) to solve for the demand based on exogenous variables:

$$\begin{aligned} s^{\star}_{igt} &= A_{igt} + \frac{\alpha E_{gt}[A]}{(1-\alpha)} - \eta P_{gt} - \frac{\alpha \eta P_{gt}}{(1-\alpha)} && (3) \\ &= A_{igt} + \frac{\alpha E_{gt}[A]}{(1-\alpha)} - \frac{\eta P_{gt}}{(1-\alpha)} && (4) \end{aligned}$$

Eq. (3) explicitly shows the two channels through which price influences behavior when endogenous social interactions are non-zero. The third term on the right-hand-side is the direct effect of price on $s^{\star}_{igt}$. A unit increase in P_{gt} increases the marginal (utility) cost of each unit of s_{igt} by η. The fourth term is the indirect effect of price that works through the reference level $E_{gt}[s]$. Because every individual in community g is affected by the price increase $E_{gt}[s]$ declines. This creates a feedback effect as all individuals further decrease s_{igt} in response to the decreases in $E_{gt}[s]$. The equilibrium magnitude of this indirect effect is a $\alpha\eta/(1-\alpha)$ unit decrease in $s^{\star}_{igt}$ for a unit increase in price.[2] The sum of these two effects corresponds to the price coefficient in (4). This highlights the previously mentioned aggregation problem; in the presence of endogenous social interactions the effect of price on group behavior cannot be determined by aggregating the direct effect of price on individual behavior.

2.1 Identification

The composite variable A_{igt} from Eq. (4) is specified as the sum of observable and unobservable influences on the outcome:

$$\begin{aligned} &A_{igt} = X'_{igt}\beta_1 + Z'_{igt}\beta_2 + E_{gt}\left[X\right]'\theta_1 + I'_{gt}\theta_2 + \delta_g + \psi_t + \epsilon_{igt} \\ &E_{gt}\left[\epsilon_{igt}\right] = 0, \quad E_{gt}\left[\epsilon^2_{igt}\right] = \sigma^{\epsilon}_{g}. \end{aligned} \qquad (5)$$

The $1 \times l$ vector Z_{igt} and $1 \times k$ vector X_{igt} both include exogenous characteristics specific to individual i. Importantly, Z_{igt} represents characteristics that exclusively influence individual i and X_{igt} represents characteristics that, in aggregate, may directly influence the preferences

[2]Notice that $\alpha\eta/(1-\alpha)$ is equivalent to the infinite sum $\lambda = \eta\sum_{n=0}^{\infty}\alpha^n$.

of others in the community. The aggregate influence is captured by the inclusion of $E_{gt}[X]$, a vector of the mean values of X_{igt} within community g. I_{gt} is a vector of other observable community characteristics that impact individual tobacco preferences. Unobserved factors that influence preferences for tobacco are captured by $\delta_g + \psi_t + \epsilon_{igt}$, where δ_g is unobservable factors corresponding to the community, ψ_t is common unobserved factors over time, and ϵ_{igt} is unobservable factors corresponding to the individual. The following assumptions are made with respect to the distribution of unobservables: 1) δ_g is constant over the time period under consideration; 2) conditional on X_{igt}, Z_{igt} and I_{gt}, ϵ_{igt} is independently but not identically distributed across communities. The first assumption means that community level fixed effects can be used to control for δ_g[3]. The second assumption allows that disturbances may be correlated within communities and standard errors need to be clustered by community when estimating.

Coefficients are interpreted following Manski (1993). The $l \times 1$ and $k \times 1$ vectors of coefficients, β_1 and β_2, correspond to the private effect of each exogenous variable on the cigarette consumption of individual i. For example, an individual's age may directly impact propensity to smoke. In addition to the endogenous social effect, α from Eq. (2), there is a second social effect, known as the contextual effect, captured by the $k \times 1$ and $m \times 1$ vectors θ_1 and θ_2. The contextual effect captures the influence on individual tobacco use of observable community characteristics. For example, living in a community with high levels of income inequality may place stress on all community members (Wilkenson and Pickett, 2007) which leads to greater tobacco use (Rahkonen *et al*, 2005). Therefore, changes in income inequality will effectively coordinate changes in tobacco use for individuals in the community. δ_g corresponds to Manski's correlated effects. In the current context, a correlated effect is present if permanent differences in traditional and spiritual use of tobacco across communities lead to differences in mean smoking behavior. As correlated effects are assumed constant over time they will be captured by including a community fixed effect.

This model of tobacco demand results in two equations from which price elasticity can be estimated. Substituting Eq. (5) into Eq. (4) yields the following reduced form estimating

[3] While difficult to provide evidence for or against this assumption, it seems intuitively likely to hold. For example, unobserved correlated effects may arise through traditional beliefs and values with respect to tobacco. Traditional and spiritual beliefs are generally slow to change and the 10 years considered here would represent a relatively short period. Another, potentially more concerning, source may be unobserved community health interventions. In Section 5 I discuss and test this channel.

equation:

$$s_{igt} = X'_{igt}\beta_1 + Z'_{igt}\beta_2 + E_{gt}\left[X\right]' \frac{\alpha\beta_1 + \theta_1}{1-\alpha} + E_{gt}\left[Z\right]' \frac{\alpha\beta_2}{1-\alpha} + I'_{gt}\frac{\theta_2}{1-\alpha} + \frac{\eta P_{gt}}{1-\alpha} + \frac{\delta_g + \psi_t}{1-\alpha} + \epsilon_{igt}. \tag{6}$$

Notice that the coefficients for variables that affect the entire group all contain the social multiplier, $1/(1-\alpha)$.

The second estimating equation uses the two-stage strategy outlined by Graham and Hahn (2005) to estimate the structural equation directly. In the first stage the elements of $E_{gt}\left[Z\right]$ are used as excluded instruments to estimate $E_{gt}\left[s\right]$. In the second stage the correspondent predicted values of $\widehat{E_{gt}\left[s\right]}$ to estimate (4) directly. This estimation strategy is summarized by the following equations:

$$\widehat{E_{gt}\left[s\right]} = E_{gt}\left[X\right]' \frac{\beta_1 + \theta_1}{1-\alpha} + E_{gt}\left[Z\right]' \frac{\beta_2}{1-\alpha} + I'_{gt}\frac{\theta_2}{1-\alpha} + \frac{\eta P_{gt}}{1-\alpha} + \frac{\delta_g + \psi_t}{1-\alpha} \tag{7}$$

$$s_{igt} = X'_{igt}\beta_1 + Z'_{igt}\beta_2 + \alpha\widehat{E_{gt}\left[s\right]} + E_{gt}\left[X\right]'\theta_1 + I'_{gt}\theta_2 + \eta P_{gt} + \delta_g + \psi_t + \epsilon_{igt}. \tag{8}$$

In this strategy, the between-community variation in the change in community averages for Z_{igt} over time identifies the effect of community tobacco use on individual tobacco use (α in Eq. (8)).

Notice that the extent to which Eq. (6) and Eq. (8) yield different estimates of price elasticity depends on the magnitude of α. If $\alpha = 0$ then the coefficients associated with price for the two equations will be approximately equivalent. If $0 < \alpha < 1$, then the price coefficient for Eq. (6) will be strictly larger than the price coefficient for Eq. (8). Further, the two price coefficients will differ by $1/(1-\alpha)$ where α is estimated directly in Eq. (8).

2.2 Empirical application

The data—discussed in greater detail in Section 3—used to estimate equations (6) and (8) is a randomly drawn sample from two time periods (1991 and 2001) and 95 distinct communities. X_{igt} includes a quadratic age term, a sex indicator, household size, marital status, family and respondent income (in $100,000 increments), employment status, and current student status. I_{gt} includes the within-community standard deviation of personal income.

Z_{igt} includes two variables for which the absence of a contextual effect is plausible. The first is high-school graduation status. Previous work has shown that education has a causal effect on individual smoking. Across a number of different smoking outcomes de Walque

(2007) estimates the causal effect of education to be close to that obtained from OLS. There are a number of explanations for this relationship. Education may change the perceived value of the future, or change the way an individual discounts the future. More educated individuals may be better able to process information that is disseminated about the health risks of tobacco (de Walque, 2010). Attending school may increase the probability of being exposed to an anti-smoking intervention, although the effectiveness of these interventions is questionable (for example see Nutbeam *et al*, 1993). Conditioning on own education, I assume that an individual's tobacco use is influenced by the community rate of high school graduation only indirectly through aggregate tobacco use. This assumption is violated if, independent of their own tobacco use, more educated community members are more likely to support anti-smoking programs and such programs have a measurable effect. In this case, estimates will falsely attribute the correlation between individual tobacco use and the community high school graduation rate to endogenous social interactions rather than to the unobserved policy interventions. This is unlikely to be the case as, relative to other health and economic concerns, smoking is not viewed as problematic in these communities. The 1991 Aboriginal Peoples Survey asks respondents to identify the three most serious community health issues. Only 0.2 percent of respondents identify smoking in this list.[4] Compare this to 11.1 percent who identify psychological health, 13.3 percent who identify alcohol, drug and solvent abuse, and 25.6 percent who identify diabetes. Further, of the few respondents who identify smoking, there is not a significant correlation with education.

The second variable in Z_{igt} is a *community problem index*. The community problem index is constructed based on the answers to seven binary response questions regarding whether the respondent thought various social issues where a problem in the community (none referring to smoking).[5] The index is the proportion of these questions for which an affirmative response is given. The community problem index captures individual perceptions of community health. If perceiving a greater number of problems leads to greater stress, a positive relationship between the index and tobacco is expected. However, conditioning on one's own perception of the social problems in the community the perception of other community members should only effect the individual's tobacco use if it effects aggregate tobacco use.

The identification strategy uses between-community variation in the change in community averages for Z_{igt} between the two time periods—variation in $E_{g2001}[Z] - E_{g1991}[Z]$—to

[4] The 1991 Aboriginal Peoples Survey included questions (D3_3A1–D3_3A3) asking the respondent to choose from a list of 26+"other" health concerns the three most serious community health problems.

[5] The seven questions ask if the respondent believes *suicide, unemployment, family violence, rape, sexual abuse, drug abuse* or *alcohol abuse* are problems in the community.

identify the effect of community tobacco use on individual tobacco use (α in Eq. (8)). The between-community means and standard deviations for the two variables in $E_{g2001}[Z] - E_{g1991}[Z]$ are summarized in the far right column of Table 1. The intuition underlying this exclusion restriction is captured by the following thought experiment: Consider a moving a randomly chosen individual from his current community to a hypothetical community which is observably identical, including tobacco use, except that the high-school graduation rate is 10 percent higher. The exclusion restriction means that the individual will not have a different pattern of tobacco use in the second community than in the first. The sensitivity of estimates to deviations form the exclusion restriction on Z_{igt} is examined in Section 5.

Sample analogs for $E_{gt}[X]$ and $E_{gt}[Z]$ are constructed using the population weights provided in the survey and all observations available for each community.[6] Summary statistics for these variables are provided in Table 1.

Table 1

3 Data

The primary data for this study are drawn from the 1991 and 2001 waves of the Aboriginal Peoples Survey (APS), a post-census survey administered by Statistics Canada. The confidential micro-data are accessed through the Statistics Canada's Research Data Center. Communities are identified by unique census sub-division codes. I restrict the sample to communities that are sampled in both the 1991 and 2001 APS and exclude communities with less than 45 observations in each period[7]. The result is a total of 95 First Nations

[6]The use of sample analogs may bias estimates toward zero. To see this write Eq. (6) in sample analogs:

$$s_{igt} = X'_{igt}\beta_1 + Z'_{igt}\beta_2 + \bar{X}'_{gt}\frac{\alpha\beta_1+\theta_1}{1-\alpha} + \bar{Z}'_{gt}\frac{\alpha\beta_2}{1-\alpha} + I'_{gt}\frac{\alpha\theta_2}{1-\alpha} + \frac{\eta P_{gt}}{1-\alpha} + \frac{\delta_g+\psi_t}{1-\alpha} + u_{igt}$$

where

$$u_{igt} = \left(E_{gt}[X] - \bar{X}_{gt}\right)\frac{\alpha\beta_1+\theta_1}{1-\alpha} + \left(E_{gt}[Z] - \bar{Z}_{gt}\right)\frac{\alpha\beta_2}{1-\alpha} + \epsilon_{igt} = e^X_{gt} + e^Z_{gt} + \epsilon_{igt}$$

It is assumed that measurement error in the explanatory variables is uncorrelated with the random error component: $E\left[e^X_{gt}, \epsilon_{igt}\right] = 0$ and $E\left[e^Z_{gt}, \epsilon_{igt}\right] = 0$. This implies that the sample is randomly selected (see Section 3 for a discussion of data sampling). Further I assume that individual characteristics are measured without error. Ammermueller and Pischke (2009) discuss the additional complications faced with selection bias and error-in-variables. I use a split-sample IV estimation approach (as in Auld (2011)) to address the attenuation bias resulting from random error. Unfortunately this strategy results in dramatically larger standard errors, likely due to the relatively small community samples, and is not reported. Therefore, coefficient estimates for community aggregates should be interpreted as under-estimating the true effect.

[7]These restrictions result in a decrease from an initial APS sample of 181 and 123 communities and 25,122 and 45,710 observations, to a sample of 11,090 and 12,910 observations observations, in 1991 and

reserves[8] consisting of 24,400 individuals (an average 23 percent sample for each community based on 2001 census populations) from which sample analogs for community means are calculated. For regression estimation, data is restricted to respondents between the ages of 18 and 60, dropping 4,890 observations. Further, observations missing any outcome or control variables, a total of 1,390, are omitted[9]. The final regression sample consists of 17,720 individual observations.

The APS is not a representative sample of First Nations reserves in Canada. Survey participation is voluntary and conditional on Census participation. As many reserves do not participate in the Census the APS under-represents communities in Ontario, Quebec and Eastern Canada. All long form (form 2B) 1991 Census respondents who reported at least one Aboriginal origin[10] received the 1991 APS (Statistics Canada, 1995). The response rate for the 1991 APS is 87 percent. Likewise, long form (form 2D for on-reserve respondents) 2001 Census respondents who either reported Aboriginal ancestry (question 17) or identified themselves as Aboriginal (questions 18, 20 or 21) are targeted for the 2001 wave of the APS with an on-reserve response rate of 88 percent (Statistics Canada, 2003). Due to cost considerations, the 2001 survey sampled 50 to 55 percent of the participating communities in each province, beginning with the largest. In the case of British Columbia, where there are many small reserves, less than 50 percent of the communities are surveyed.

3.1 Tobacco use in First Nations reserves

Tobacco use summary statistics are presented in Table 2. Smoking rates are high in these communities relative to the Canadian average (12 percent) and the population of Aboriginal Canadians living off-reserve (48 percent).[11] 60 and 58 percent of respondents indicated that they smoked cigarettes in the 1991 and 2001 surveys. Daily cigarette smoking increased slightly between surveys, from 41 to 43 percent of respondents. Smoking intensity (measured by the number of cigarettes smoked per day) decreased by about two cigarettes per day between 1991 and 2001.

2001 respectively. For further details please consult the supplementary appendix

[8] A complete list of all these communities can be found in the Appendix.

[9] Please consult the supplementary appendix for more details and sensitivity analysis with respect to these observations.

[10] Aboriginal origin is defined as having identified ethnic origin as North American Indian, Métis or Inuit (Census form question 15), or as registered under the Indian Act (Census form question 16.)

[11] The Canadian average reflects the 2003 rate reported by Health Canada (2009), the off-reserve average reflects the 2001 rate for Southern Canada reported by Statistics Canada on their website: http://www.statcan.gc.ca/pub/82-003-x/2009004/article/10934/figures/fig2-eng.htm.

Similar to non-Aboriginal communities, the average age of initiation for tobacco use is 16 years. Smokers who successfully quit do so at an average age of 31, and the average daily smoker has been smoking for 17.5 years. Finally, in the 1991 survey, 69 percent of respondents (both smokers and non-smokers) indicate that at least one smoker, other than themselves, lives in their household.

Table 2

3.2 Community level referencing

A priori identification of the reference group for each individual observation is critical to the incorporation of social effects in empirical estimation (Manski, 1993, 2000). In this study it is assumed that an individual's reference group is other individuals in the same community. To show that this is a reasonable assumption, in this section the geographic, social and economic structure of the communities in this sample is discussed. The reference group assumption is based on the fact that these communities are relatively small, secluded, and self-sufficient. Migration in and out of the communities is also relatively low.

Many of the communities, particularly those in the North, are located in relatively unpopulated regions of Canada and a significant distance from major city centers. These communities are relatively self-sufficient. Based on a 2003 report, 74 percent have schools and recreation centers, 80 percent have health care centers, and 60 and 48 percent have fire and police services.[12] In 1991 50 percent of actively employed respondents worked in the community, a number that increased to 78 percent in 2001 (see Table 1).[13]

To live on a First Nations reserve an individual must be a member of the First Nations band which governs the reserve. Sections 6 and 10 of the *Indian Act* outline the criteria band membership. In practice, band membership is most often gained through birth or marriage(Assembly of First Nations, 2008).[14] Although economic opportunities are few on many reserves, there are non-trivial benefits to living on a reserve in terms of housing provision (Alcantara and Flanagan, 2002) and tax exemptions (Gardner-O'Toole, 1992). The barriers to entry and relative benefits of reserve life likely explain the low movement into and

[12]The respective infrastructure for each community is reported in the Appendix. All information is found at the Government of Canada's Aboriginal Canada Portal website: `http://www.aboriginalcanada.gc.ca/acp/site.nsf/eng/index.html` .

[13]The increase in on-reserve employment is likely, in part, a response to 1995 changes to income tax exemptions. The changes required that tax-exempt exempt employment take place on reserve.

[14]Prior to the 1985 amendments to the *Indian Act*, status by birth required the father be a registered Indian (Assembly of First Nations, 2008).

out of these communities, as reflected in the APS data (Table 2). The number of respondents who report having lived in the community their entire life was 46 percent in 1991 and 69 percent in 2001. Only 10 and 18 percent of respondents, for 1991 and 2001, report having lived outside of the community within five years of the survey.

A selection bias will result if aggregate tobacco consumption influences an individual's decision to remain on or move off their reserve. Individuals with strong anti-smoking sentiments may choose to move off a reserve with high smoking rates, but stay on a reserve with low smoking rates. This will lead to a spurious correlation between aggregate tobacco consumption and individual tobacco consumption attributable to endogenous community selection rather than endogenous social effects. My estimation of endogenous social effects assumes that this problem is sufficiently insignificant. This assumption is supported by a relatively constant (or increasing) population size in all reserves over the time period of interest and the low mobility rates reported in Table 2. Further, a study conducted by the Institute of Urban Studies (2003) found that, for families that moved from reserves to the city of Winnipeg, 90 percent of respondents cited family, employment, and education as being their primary reasons for moving. Only 1.3 percent of respondents cited alcohol and substance abuse as the primary motivate for leaving the reserve. Given this, the number of relocations due to tobacco use is likely very small.

3.3 Tobacco taxation in First Nations reserves

Section 87 of the *Indian Act* exempts all Status Indians from provincial sales taxes levied on tobacco (Gardner-O'Toole, 1992). To qualify for exemption, tobacco products must be purchased on a reserve, and the purchaser must present proof of Status. Some provinces impose a quota on the amount of tobacco an individual can purchase over a defined period (Physicians for a Smoke Free Canada, 2007), but these quotas are large relative to the needs of individual smokers and will not be considered in the analysis.[15] Status Indians are not exempt from federal excise taxes on tobacco (Physicians for a Smoke Free Canada, 2007).

Tobacco price information for individual communities between 1991 and 2001 is not available. Therefore, tobacco prices in this study reflect the average price by year and province for Status Indians purchasing on a reserve (the exception is the Kamloops reserve which implemented a First Nations Tax.) Prices, summarized in Table 3, are constructed using average provincial prices and information on the implementation of tax exemptions.

[15]For example, Alberta imposes a 4-carton, or 800 cigarettes, per week per individual quota.

Exogenous price variation comes from three sources. The first is federal excise tax reductions in the early 1990s, which were larger in the Eastern provinces than the Western provinces. Second, band councils have the authority to implement a First Nations Tax (FNT) in the communities they oversee. In 1998 the Kamloops Band became one of only 11 bands in Canada (and the only in this sample) to implement a 7 percent FNT on tobacco products sold on the Kamloops reserve[16] (Physicians for a Smoke Free Canada, 2007). Finally, variation comes from differences in how provincial tax exemptions are implemented. The province of Saskatchewan did not recognize tax exemptions until March 30, 2000 (Saskatchewan Department of Finance, 2010), which resulted in a 39 percent decrease in the point-of-sale price of tobacco in Saskatchewan between 1999 and 2000. For communities in the province of Manitoba and the Lennox Island reserve in Prince Edward Island (included in the sample), taxes are applied at the retail level and reimbursed to local First Nations band councils (Physicians for a Smoke Free Canada, 2007). As the interest of this study is the point-of-sale price, these communities are treated as fully reflecting the provincial tobacco tax.

Table 3

Tobacco prices on-reserve are never greater than tobacco prices off-reserve. However, due to changes in provincial tobacco tax rates between 1991 and 2001, prices tend to be more volatile off-reserve. Notable exceptions are in Manitoba, where on and off-reserve tobacco prices move in unison, and in Saskatchewan, where the 2000 exemption of provincial tobacco taxes on-reserve resulted in a large overall decrease in tobacco prices over this period.

Because cigarette prices in a given year are constant across all reserves within a province (Kamloops being the exception), I must assume that price changes are uncorrelated with any other unobservable factors that changed at the provincial level and influenced tobacco use. For example, if a decrease in tobacco prices is met with an aggressive Aboriginal tobacco education campaign implemented in a province, the influence of price on smoking behavior may be under-estimated.

4 Results

Eq. (6) and Eq. (8) are estimated for four outcomes. Three binary outcomes are considered—smoking participation, daily smoking, and occasional smoking (conditional on not being a

[16]The sample analyzed in this study contains the Kamloops 1 community. More information on the Kamloops FNT can be found at `http://www.cra-arc.gc.ca/E/pub/gi/notice92a/notice92a-e.html`.

daily smoker)—and smoking intensity, as reflected by number of cigarettes consumed per day. As all models are estimated linearly, binary outcomes are interpreted as linear probability models.[17] In addition to providing a robustness check, these four outcomes provide unique information with respect to the effect of price changes.

4.1 Reduced form estimates

In Table 4 I report the results for the reduced form estimates. Regressions include community fixed effects, a 2001-year dummy variable, and community level clustering of standard errors.

Table 4

4.1.1 Tobacco prices

As tobacco is an addictive good the effect of a price change on tobacco demand can be expected to be smaller in the the short run than in the long run (for example see Gilleskie and Strumpf, 2005). The price variation used in this study comes from policy changes taking place between 1991 and 2001. Therefore, the estimated price effects are interpreted as average long-run effects across these communities.

The estimated effect of a change in tobacco prices on tobacco use is economically non-trivial. A 10 percent increase in the price of tobacco is predicted to decrease smoking participation by 1.26 percentage points. This estimate is consistent with tobacco price elasticities estimated for non-Aboriginal population (for example see Ding (2004), Sen and Wirjanto (2009) and Franz (2008)). Estimates suggest that occasional smokers are more price sensitive than daily smokers; a 10 percent price increase reduces daily smoking by 0.91 percentage points and occasional smoking by 1.24 percentage points. This result is consistent with intuition, as occasional smoking is less likely than daily smoking to be associated with addiction. Finally, price estimates for smoking intensity suggest that a 10 percent increase in the price of tobacco will reduce average tobacco consumption by approximately 0.15 cigarettes per day.

[17]By specifying a linear-in-means framework I am able to precisely interpret estimated coefficient from the different equations. Binary outcome models have also been estimated using a probit specification. As expected, estimated marginal effects between the probit and linear estimates are very similar (see Angrist and Pischke (2008, 103–107) for a discussion on this property).

4.1.2 Individual characteristics

High school graduation and the community problem index are included in Z_{it} in Eq. (6) and Eq. (8). To be valid instruments for community smoking they must be significantly correlated with smoking at the individual level. Consistent with previous studies that show a strong negative relationship between education and tobacco use (de Walque, 2007; Cutler and Glaeser, 2007), First Nations adults who graduate high school are 11.1 percentage points less likely to smoke than those who leave high school without completion. Further, estimates are large and statistically significant across all outcomes; high school graduates are 10.7 percentage points less likely to smoke daily, 7.0 percentage points less likely to be occasional smokers, and smoke on average 2.28 fewer cigarettes per day.

The community problem index is positively correlated with daily smoking and smoking intensity; individuals who identify one more social problem (a 0.14 unit increase in the index) are 0.49 percentage points more likely to be a daily smoker and smoke 0.15 more cigarettes per day. The coefficients estimated for smoking participation and occasional smoking are economically small and statistically insignificant. These estimates are consistent with theories that tobacco is used as a coping mechanism in stressful circumstances (Rahkonen *et al.*, 2005). The community problem index reflects individual perceptions of community health (these perceptions may or may not reflect reality). It is reasonable that individuals who perceive the community in which they live as having more social problems, and therefore a higher community problem index, feel more stress and anxiety.

Other individual characteristics, included in X_{it} in Eq. (6) and Eq. (8), are consistent with the findings reported in studies for non-Aboriginal populations. The influence of demographic characteristics, marital status and income on adult tobacco use is very similar to what is found using the Current Population Survey (Cutler and Glaeser, 2007). The age-quadratic indicates that smoking participation and daily smoking increase until age 25 and decrease afterwards. The propensity for occasional smoking ends much earlier, increasing until age 18 and decreasing thereafter. Controlling for other factors, males are 1.8 percentage points less likely to be daily smokers, but consume one cigarette more per day, then their female counterparts. Married individuals are 8.1 percentage points less likely to smoke than individuals never married and smoke three-quarters of a cigarette less per day. The coefficients for household and individual income are negative and statistically significant but economically small. At best, a ten-thousand dollar increase in personal income reduces tobacco use by one percentage point. Similarly, unemployed individuals are 4.6 percentage points more likely to be smokers than those not in the labour force. The consistency of these estimates with previous work is reassuring.

Within many communities tobacco is considered a sacred plant. Therefore, individuals who are engaged in traditional Aboriginal culture may be more likely to disregard warnings about the dangers of smoking (see McKennitt (2005) for a discussion). However, ceremonial use involves consuming relatively small amounts of tobacco and is unlikely to lead to abuse. Estimates are consistent with this reasoning; individuals who speak a traditional Aboriginal language are 2.1 percentage points more likely to identify themselves as smokers, however, this is due only to an increase in occasional smoking. Individuals who speak a traditional language are no more likely than non-speakers to be daily smokers.

4.1.3 Community characteristics

A significant coefficient associated with the community means suggest that either an endogenous social effect or a contextual effect is present. Many of the coefficient estimates associated with community means are statistically insignificant but have an economically meaningful magnitude. This may be the result of low variation across communities and time leading to imprecise estimates or attenuation bias arising from the use of sample analogues in place of community means. Consider comparing two observationally equivalent individuals living in communities that are identical in every way except in one the proportion of residents under 20 years of age is 10 percentage points higher (and proportion of residents over 60 is 10 percentage points lower). The individual in the younger community is 11.4 percentage points more likely than the individual in the older community to be an occasional smoker. A 10 percentage point increase in community speaking of a traditional Aboriginal language increases the probability a given individual will be an occasional smoker by 2.26 percentage points but has an economically small and negative effect on daily smoking and smoking intensity.

Indicators of community health, specifically the mean community problem index and the standard deviation of community income, have an interesting interpretation. Conditioning on an individual's community problem index, an increase in the mean community problem index increases the probability a given individual will be a daily smoker. A mean increase of one more problem identified (increasing the index by 0.14) increases the probability of daily tobacco use by 3.38 percentage points. A ten-thousand dollar increase in the standard deviation of community income increases the probability an individual smokes by 7.96 percentage points.

It is worth noting that, under the assumption that $\alpha \geq 0$, if the coefficient for a variable in $E_{gt}[X]$ or $E_{gt}[Z]$ is a different sign than the coefficient for the corresponding variable in X_{igt} or Z_{igt} a contextual effect must be present. This is the case with being married or common law (as opposed to single). The private effect of being married is negative and statistically significant but the effect of community marriage is positive and large in magnitude. Therefore, it is likely the case that for marriage $\theta > 0$. Notice that for high school graduation and the community problem index the estimated coefficients for the community aggregates are the same sign as the estimated coefficients for the individual characteristic.

4.2 Structural estimates

The preferred estimates for Eq. (8) are reported in Table 5. As predicted by the model, estimates of β_1 and β_2 change very little relative to Table 4 and, in the interest of space, are excluded from Table 5. Eq. (8) is estimated using a two-stage generalized method of moments procedure (Stata's XTIVREG2 command) using community means of high school graduation and the community problem index as excluded instruments. To increase the instrument strength, for smoking participation and smoking intensity, only the stronger of the two instruments is used in the regression.[18] Estimates for alternative specifications are discussed in Section 5 and reported in Table 6.

Following Chernozhukov and Hansen (2008) I calculate confidence bounds for α that are robust to weak instruments (CH bounds henceforth). This involves estimating the following series of equations:

$$\tilde{s}_{igt} - \alpha_0 \widetilde{E_{gt}[s]} = \widetilde{E_{gt}[Z]}' \gamma + \upsilon_{igt} \quad \alpha_0 \in [\underline{\alpha}, \bar{\alpha}],$$

where $[\underline{\alpha}, \bar{\alpha}]$ is predetermined and a tilde indicates that all other regressors in Eq. (8) have been partialled out. A test of $\gamma = 0$ is equivalent to a test of $\alpha = \alpha_0$ and this test is independent of instrument strength (Chernozhukov and Hansen, 2008). The resulting CH bounds for α are defined by the upper and lower bounds on the set of all α_0 for which the null hypothesis of $\gamma = 0$ fails to be rejected (the corresponding F-test is calculated using robust standard errors clustered by community). For each outcome this procedure is implemented by varying α_0 is between -4.0 and 4.0 by increments of 0.005. CH bounds are reported in braces in Table 5.

[18]Following Angrist and Pischke (2009, pp.205–15). When instruments are relatively weak, the bias arising from weak instruments is inversely related to the number of weak instruments, with the just identified case being approximately unbiased. Please see the supplementary appendix for a discussion and estimates including all instruments.

Table 5

4.2.1 Tobacco prices

The direct effect of a 10 percent increase in the price of tobacco is predicted to decrease smoking participation by 0.79 percentage points. This is a little more than half the magnitude of the estimated total effect in Table 4. A similar pattern is observed for daily smoking and smoking intensity. The direct effect of a 10 percent price increase is estimated to decrease daily smoking by 0.49 percentage points and to decrease smoking intensity by about 1.17 cigarettes per day. This suggests the importance of endogenous social effects in observed outcomes: endogenous social effects increase the effect of a change in price relative to the direct effect alone.

The estimated direct price elasticity for occasional smoking is slightly larger than that reported in Table 4. This can be attributed to the fact that community high school graduation rates and the average community problem index have very low first-stage explanatory power. As a result, structural estimates for this outcome remain unidentified under this strategy. Notice that the estimated value for $\hat{\alpha}$ for this outcome is negative, and the weak-instrument bounds extend to the lower limit (-4.00).

4.2.2 Endogenous social effects

Coefficients corresponding to community aggregates for each of the outcomes are interpreted as endogenous social effects, parameter α from Eq. (2). With the exception of occasional smoking, estimates of α are large in magnitude. Consider moving a randomly chosen individual from their current community to a hypothetical community, identical in every respect except smoking participation is 10 percent higher. The move will increase that individual's propensity to smoke by 4.74 percentage points. This is consistent with endogenous social effects estimated for tobacco use by Cutler and Glaeser (2007) and Powell *et al.* (2005), but larger than those reported in Krauth (2007). However, estimates for smoking participation are not statistically significant under conventional standard errors, and the CH bounds are large and skewed left, suggesting that $\hat{\alpha}$ cannot be confidently distinguished from zero.

Estimates for daily smoking and smoking intensity suggest that α is large. 10 percentage point increase in the proportion of daily smokers increase the probability an individual smokes daily by 7.85 percentage points. Following an exogenous increase in average smoking intensity of one cigarette per day individual smoking intensity is expected to increase by 0.85 cigarettes per day. The instruments for these two outcomes are relatively strong (the first stage F-stats for excluded instruments are 5.36 for daily smoking and 7.69 for smoking intensity) and point estimates are precise. For daily smoking, the lower value of the CH bound suggests that $\alpha = 0.33$, which is a non-trivial magnitude. For smoking intensity the CH bounds are wider, with a lower value of $\alpha = 0.25$, but still suggest the point estimate statistically differs from zero and is non-trivial in magnitude.

Estimates for occasional and daily smoking are over-identified. In these cases Hansen's J is used to test the null hypothesis that exclusionary restrictions are valid. The corresponding p-values, reported at the bottom of Table 5, fail to reject the validity of the exclusionary restrictions. However, as this test is low in power, and relies on the exclusion restriction being valid for at least one instrument, the exclusion restrictions are further examined in Section 5.

5 Robustness

The above analysis relies on two key identifying assumptions: 1) unobservable correlated effects are constant over time and 2) there is no contextual effect associated with high school graduation or perceived community problems. In this section I interrogate these assumptions and consider alternative specifications for the estimation of Eq. (8).

Table 6

If community health interventions, unobserved within this study, took place between 1991 and 2001, then the first assumption above may be violated and result in confounded estimates. Such an intervention does not need to address smoking directly to be problematic. Diabetes is a serious health concern in these communities. In this sample, 11.1 percent of 2001 respondents stated they have doctor diagnosed diabetes and 25.6 percent of 1991 respondents identified diabetes as a serious health problem in their community (0.2 percent identified smoking). An intervention targeting diabetes may include a smoking cessation component. If so, a decrease in the prevalence of diabetes (or other complicating factors such as obesity) over time will be correlated with a decrease in community smoking. To account for this I include in I_{gt} the estimated rate of doctor diagnosed diabetes and obesity (identified by a body mass index greater than 30) in the preferred regression.[19] The resulting $\hat{\eta}$ and $\hat{\alpha}$, presented in Panel A of Table 6, change little from previous estimates. For smoking participation, $\hat{\alpha}$ increases to 0.484 with a, still insignificant, CH bound of {-0.410, 0.969}.

[19]Regressions with diabetes and obesity separately yield similar results.

Estimates for daily smoking and smoking intensity are very close to those in Table 5. This suggests that any confounding effect arising from unobserved health interventions over time does not seriously affect the estimates in Table 5.

Estimates using alternative specifications for Eq. (8) are presented in panels B and C of Table 6. In Panel B only speaking of traditional language and the standard deviation of community income are included as aggregates in both the first and second stage. This is equivalent to imposing the strong assumption that all remaining community aggregates have no contextual effects and can be used as excluded instruments.[20] Under this specification $\hat{\alpha}$ decreases for smoking participation, daily smoking and smoking intensity. For occasional smoking $\hat{\alpha}$ is positive and of a reasonable magnitude (although the bounds on this estimate remain large). Further, the estimated price effect for occasional smoking is now half the size of the estimated total effect, consistent with the underlying model. However, the first stage instruments remain too weak, and the underlying assumptions are too strong, to be confident in this result. In Panel C estimates are reported for regressions that exclude a number of the community aggregates are from the first and second stage. This addresses the concern that collinearity, arising from the use of many community aggregates, is leading to very imprecise estimates. For all outcomes I drop the proportion of males, average household size, average family and respondent income and proportion unemployed. Further, for smoking participation and smoking intensity I also drop proportion employed.[21] Relative to the estimates reported in Table 5, there is only a slight decrease in the point estimates.[22] I conclude that the main findings of this study are not sensitive to the alternative specifications reported in Table 6.

Finally, I turn to examining the second assumption mentioned above. Conley, Hansen and Rossi (2012) provide a method of testing the sensitivity of structural estimates to small deviations from the exclusion restriction implied by this assumption. Intuitively, this involves assigning a predetermined value for the contextual effect, θ_0, of the instrument of concern

[20]Including all of these aggregates as instruments leads to very low first stage F-statistics. Therefore, following Angrist and Pischke (2009, pp.205–15), only the original instruments are included in the first stage.

[21]The p-values corresponding to an F-test of the joint significance of the dropped variables in the first (second) stage regression are 0.21(0.39) for smoking participation, 0.78(0.70) for occasional smoking, 0.41(0.47) for daily smoking, and 0.70(0.30) for smoking intensity.

[22]It should be cautioned that the standard errors of these estimates have not been corrected for variable pre-selection (Wong, 1997). This correction will likely lead to confidence intervals wider than those reported in Panel C.

and re-estimating the second stage structural equation:

$$s_{igt} - E_{gt}[Z]'\theta_0 = X'_{igt}\beta_1 + Z'_{igt}\beta_2 + \alpha\widehat{E_{gt}[s]} + E_{gt}[X]'\theta_1 + I'_{gt}\theta_2 + \eta P_{gt} + \delta_g + \psi_t + \epsilon_{igt} \quad \theta_0 \in \left[\underline{\theta}, \bar{\theta}\right].$$

Repeating this exercise for each $\theta_0 \in \left[\underline{\theta}, \bar{\theta}\right]$ will yield a corresponding set estimate for α. The confidence interval for this set is the union of confidence intervals for each $\alpha(\theta_0)$. If contextual effects associated with Z_{igt} are important then $\hat{\alpha}$ will be sensitive to changing values of θ_0.

To define the bounds on $\left[\underline{\theta}, \bar{\theta}\right]$ I assume that the magnitude of the contextual effect associated with the instrument is no more than half the magnitude of the private effect associated with the corresponding variable. For example, for smoking participation the private effect associated with high school graduation is -0.11. Therefore, the maximum magnitude the contextual effect of the community high school graduation rate is $|0.06|$. Further, for high school graduation, I assume that the contextual effect is negative. This implies that the direct effect of a 10 percent change in the high school graduation rates is roughly the same magnitude as the estimated direct effect of a 10 percent increase in the price of tobacco. For the community problem index I consider both positive and negative bounds symmetric about zero.

Figure 1

The results of the sensitivity analysis are reported in Figure 1. For each of the binary outcomes I report the analysis for the high school graduation rate only, for smoking intensity I report the results for the community problem index. In the figures to the left and right I report estimates for α and η respectively over different values of θ_0. In each figure, θ_0 is on the horizontal axis, the solid line depicts point estimates, the dashed lines depict 90 percent asymptotic confidence interval, the fine dashed lines depict 90 CH bounds (with a minimum lower bound of -4.0).

Imposing a negative contextual effect associated with the high school rate leads to a smaller point estimate for the endogenous social effect. For smoking participation, with a contextual effect in the set $[-0.06, 0]$, the corresponding point estimate set is $[0.21, 0.47]$. While this set suggests a point estimate that is economically non-trivial, both the asymptotic confidence intervals and CH bounds suggest that zero cannot statistically be excluded from the estimates. The estimated endogenous social effect for daily smoking is robust to this sensitivity test. For a contextual effect in the set $[-0.05, 0]$ point estimates are $[0.72, 0.78]$ with 90 percent CH bounds of $\{0.23, 0.97\}$. Notice that even at the lower CH bound, the implied endogenous social effect for daily smoking is relatively large. For smoking intensity, with the community problem index contextual effect varying between $[-0.50, 0.50]$, the point estimates remain large in magnitude, $[0.73, 0.97]$, and the corresponding CH bounds, $\{0.02, 1.42\}$, widen but remain positive.

Estimates of the direct price elasticity, η, are relatively stable to this sensitivity test. For smoking participation the set of point estimates is $[-0.11, -0.08]$ with a confidence interval of $(-0.21, -0.002)$. The point estimate set for daily smoking is narrow, $[-0.053, -0.049]$, and statistically significant with a confidence interval of $(-0.09, -0.01)$. For smoking intensity estimates are also stable with point estimates between $[-1.23, -1.11]$ and a corresponding confidence interval of $(-2.31, -0.15)$.

The sensitivity analysis suggests that the structural estimates for Eq. (8) are reasonably robust to deviations in the exclusion restrictions.

6 Conclusions

Using the 1991 and 2001 waves of the Aboriginal Peoples Survey I create a repeated cross-section of Canadian First Nations reserves and use it to analyze smoking behavior. Three important contributions are made: i) I estimate the direct and the total effect of a tobacco tax on smoking. ii) I estimate the community level impact of endogenous social interactions on adult smoking. iii) I provide the the first estimates of tobacco price elasticity in Canada's First Nations reserves.

Does ignoring social effects when estimating price elasticity affect results? To answer this question consider an estimating Eq. (8) under the assumption that $\alpha = 0$. When $\theta_1 = \theta_2 = 0$, implying observable community characteristics are also ignored, the estimated price effects for smoking participation, occasional smoking, daily smoking and smoking intensity are -0.067, -0.047, -0.075 and -1.026. When observable community characteristics in $E_{gt}[X]$ and I_{gt}, but not $E_{gt}[Z]$ are included the respective estimates are -0.103, -0.140, -0.053, and -1.088. Notice that for smoking participation, daily smoking and occasional smoking estimates are consistent with the direct effect. From a policy perspective it is the total effect that is of interest. This illustrates the importance of explicitly modelling the underlying theory to ensure that we know which price effect is being estimated.

Previous policy studies suggest that the tobacco tax is an important instrument to address high rates of tobacco consumption on First Nations reserves. For example, Samji and Wardman (2009) hypothesize that a 7 percent First Nations Tax (FNT) will reduce smoking rates by 2.4 percent and provincial tax rate (50 percent) will reduce smoking rates by 22.5 percent.[23] My estimates suggest that the effect of tax policy on adult tobacco consumption will be about half this size: relative to 2001 levels, smoking participation rates for Aboriginal adults will decrease by 1.52 percent (0.88 percentage points) following a 7 percent FNT and 10.86 percent (6.30 percentage points) following a provincial tax. Further, a tax will have a greater proportional effect on occasional smoking than daily smoking. A 50 percent tax will decrease daily smoking by 10.58 percent and occasional smoking by 41.33 percent from 2001 levels.

The ability to identify an individual's community allows me to identify a feasible reference group and to provide meaningful information about the relationship between policy intervention and social interactions. For smoking participation, daily smoking and smoking intensity I find that social interactions result in a non-trivial increase in the negative influence of price on adult tobacco use over the direct effect alone (given the results reported in Table 4 and Table 5.) Further, some interesting contextual effects are identified for occasional tobacco use. In particular, greater traditional language use, both by individuals and for the community aggregate, increases the probability of occasional smoking. One interpretation of this is that ties to traditional culture lead to ceremonial use of tobacco. Interestingly, there is no corresponding relationship with daily tobacco use.

The results of this study have relevance beyond smoking on First Nations reserves. One may worry endogenous social effects are larger in these communities than in non-Aboriginal populations. This concern can be mitigated by noting that the estimated total price effect is similar in magnitude to estimates from non-Aboriginal adult populations. If endogenous social effects are larger, then the direct price effect must be weaker in First Nations reserves than in non-Aboriginal communities. This seems unlikely, given that on-reserve household income is well below the Canadian average. Further, the analysis in this study will apply to any socially influenced good or behavior, such as obesity and low physical activity, drug and alcohol use, or education and labour force participation.

The importance of endogenous social interactions needs to be considered in policy design. First, policy interventions that are applied to a sub-group within the population will have meaningful spillovers to the larger population. For example, the availability of quit-smoking assistance in the work place will impact smoking in the larger community. Second, broadly applied interventions will be more effective (i.e. have a larger “multiplier”) than narrowly

[23] The predicted effect of tobacco taxation in Samji and Wardman (2009) is based on an elasticity estimated for non-Aboriginal populations by the U.S. Department of Health and Human Services.

focused interventions. Third, when only the direct effect of an intervention is know, as may be the case in trial studies randomized across individuals, we cannot determine the effectiveness of a policy by aggregating individual behavior. Estimates of the endogenous social effect provide a mechanism for adjusting from randomized trial to large-scale policy.

Further research is warranted to address this study's limitations. Much of the estimation relies on the variation in community aggregates over time. Because sample analogs are used in place of the true aggregates, corresponding coefficient estimates are prone to attenuation bias as a result of error-in-variables. Further, community aggregates tend to change very slowly, limiting the within-variation available to exploit. Therefore, the fixed effects estimates produce large standard errors and instruments which, by conventional measures, are weak. This is most problematic for occasional smoking where the empirical strategy does not appear to successfully identify the structural equation. A strong instrument, preferably generated through a randomized-control field study, will significantly improve the analyses.

The study of Canada's on-reserve First Nations population is limited by access to reliable data. Waves of the APS that follow the 2001 survey (2006, 2011) are limited to individuals living off-reserve.[24] Continued collection of information from these communities will greatly improve our ability to study and make policy recommendations with respect to this important segment of the Canadian population.

Likewise, the empirical identification of social effects more generally is limited by data availability. Surveys that include questions directed at identifying reference group behaviors are vital to move this research forward. Given the importance of this information for health and social policy research, ensuring such information is collected in national data should be high priority.

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[24]Since 2001 data collection for First Nations reserves is primarily controlled by the First Nations Information Governance Centre.

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Table 1: Demographic, income and labour summary statistics

	1991				2001				1991–2001	
	Mean	SDW	SDB	N	Mean	SDW	SDB	N	Δ	SDΔ
X_{igt}										
Age	34.75	15.97	2.25	11,090	36.09	15.78	2.36	12,920	1.58	1.81
Males	0.52	0.50	0.05	11,090	0.50	0.50	0.04	12,930	0.00	0.06
Household size	5.55	2.57	0.98	11,090	4.89	2.29	0.84	12,770	-0.64	0.64
Married	0.88	0.92	0.20	11,090	0.75	0.89	0.18	12,770	0.01	0.04
Family income	20,875	18,296	8,176	11,090	24,864	23,187	9,373	12,770	4,400	6,126
Personal income	9,048	10,161	1,957	11,090	12,784	13,429	3,179	12,770	3,736	2,781
Employed	0.31	0.45	0.09	11,030	0.39	0.48	0.10	12,570	0.08	0.10
Unemployed	0.15	0.35	0.07	11,030	0.12	0.31	0.05	12,570	-0.03	0.08
Speaks a trad. language	0.84	0.23	0.21	10,930	0.80	0.31	0.20	12,890	-0.04	0.12
Attending School	0.17	0.37	0.05	11,090	0.12	0.33	0.04	12,470	-0.01	0.07
Z_{igt}										
High school grad.	0.15	0.34	0.08	9,570	0.23	0.41	0.09	11,390	0.09	0.07
Com. problem index	0.51	0.26	0.11	10,680	0.61	0.27	0.10	12,520	0.10	0.11

SDW and SDB are standard deviations within and between communities, Δ is the average change in mean community values between 1991 and 2001 and SDΔ is the between community standard deviation in the change between 1991 and 2001. 95 communities covered. Population weights used in all calculations. N, the number of observations, is rounded for confidentiality requirements.

Table 2: Tobacco use and mobility summary statistics

	1991				2001			
	Mean	SDW	SDB	N	Mean	SDW	SDB	N
Tobacco use								
Smokers	0.60	0.48	0.10	10,840	0.58	0.48	0.11	12,480
Daily smokers	0.41	0.48	0.11	10,840	0.43	0.48	0.12	12,480
Cig. per day (daily)	14.78	9.26	3.30	4,509	12.07	7.20	2.41	5,320
Cig. per day (occasional)					4.98	3.93	1.28	1,790
Age started					16.05	4.80	1.09	5,240
Age stopped					31.47	13.31	3.39	1,900
Years smoked					17.48	12.45	3.26	5,240
Other smokers in household	0.69	0.45	0.12	10,811				
Mobility								
Lived on reserve entire life	0.46	0.46	0.196	10,829	0.69	0.44	0.131	12,840
Lived off reserve past 5 years	0.10	0.28	0.061	11,081	0.18	0.365	0.098	10,560
Currently works on reserve	0.50	0.37	0.310	5,715	0.78	0.34	0.202	5,710

SDW and SDB are standard deviations for within and between communities. 95 communities covered. Population weights used in all calculations. N, the number of observations, is rounded for confidentiality requirements.

Table 3: Cigarette prices in survey years

Province	1991	2001	% Change	Communities
Newfoundland	35.32	32.42	-8.21	1
Prince Edward Island	52.08	44.48	-14.59	2
Nova Scotia	37.50	31.47	-16.08	3
New Brunswick	39.36	35.33	-10.24	1
Quebec	33.53	26.87	-19.86	3
Ontario	36.11	28.86	-20.08	7
Manitoba	53.27	51.28	-3.74	14
Saskatchewan	50.88	30.73	-39.60	30
Alberta	31.85	28.36	-10.96	12
British Columbia	30.40	28.15	-7.40	21
Kamloops	30.40	30.12	-0.92	1

Prices reflect the real price of 200 cigarettes for Status Indians purchasing on reserve. Nominal prices are adjusted using provincial consumer price index (2001 dollars.)

Table 4: Reduced form equation estimates

	Smoking participation	Occasional smoking	Daily smoking	Cigarettes per. day
log(Cigarette prices)	-0.126***	-0.124*	-0.091	-1.526
	(-0.195, -0.056)	(-0.228, -0.020)	(-0.187, 0.005)	(-3.408, 0.356)
Individual characteristics				
Age	0.011***	0.005*	0.009***	0.412***
	(0.007, 0.015)	(0.000, 0.010)	(0.005, 0.013)	(0.330, 0.495)
Age-squared/100	-0.022***	-0.014***	-0.017***	-0.574***
	(-0.027, -0.017)	(-0.020, -0.007)	(-0.022, -0.012)	(-0.674, -0.475)
Male	-0.014	-0.004	-0.018*	1.009***
	(-0.029, 0.001)	(-0.020, 0.012)	(-0.033, -0.002)	(0.670, 1.348)
Household size	0.005***	0.007***	0.002	0.002***
	(0.002, 0.008)	(0.004, 0.011)	(-0.001, 0.006)	(-0.074, 0.078)
Divorced/sept./wid.	0.026	-0.008	0.036**	1.255***
	(-0.000, 0.052)	(-0.039, 0.022)	(0.010, 0.063)	(0.588, 1.922)
Married	-0.081***	-0.075***	-0.057***	-0.790***
	(-0.098, -0.065)	(-0.096, -0.054)	(-0.072, -0.041)	(-1.187, -0.394)
Family income‡	-0.090***	-0.109***	-0.048**	-0.981**
	(-0.125, -0.056)	(-0.148, -0.069)	(-0.078, -0.017)	(-1.631, -0.331)
Respondent income‡	-0.106***	-0.092**	-0.060*	-2.084**
	(-0.161, -0.051)	(-0.154, -0.029)	(-0.118, -0.002)	(-3.418, -0.749)
Employed	-0.001	-0.004	0.001	0.047
	(-0.016, 0.015)	(-0.023, 0.015)	(-0.017, 0.018)	(-0.282, 0.376)
Unemployed	0.046***	0.044***	0.030***	0.622**
	(0.029, 0.063)	(0.019, 0.068)	(0.013, 0.048)	(0.167, 1.077)
Trad. language	0.021**	0.037***	-0.000	-0.273
	(0.004, 0.037)	(0.016, 0.059)	(-0.017, 0.016)	(-0.635, 0.089)
Attending school	-0.017	-0.023	-0.010	-1.101***
	(-0.044, 0.010)	(-0.059, 0.013)	(-0.037, 0.016)	(-1.630, -0.573)
High school grad.	-0.111***	-0.070***	-0.107***	-2.283***
	(-0.130, -0.093)	(-0.089, -0.050)	(-0.124, -0.089)	(-2.745, -1.822)
Com. problem index	0.005	-0.022	0.035**	1.101***
	(-0.017, 0.028)	(-0.051, 0.007)	(0.008, 0.062)	(0.552, 1.649)
Community means				
SD of income‡	0.796**	0.275	0.880**	13.624
	(0.161, 1.431)	(-0.631, 1.182)	(0.151, 1.609)	(-0.383, 27.631)
Age < 20yrs	0.425	1.136**	-0.157	-1.273
	(-0.248, 1.098)	(0.322, 1.949)	(-1.025, 0.710)	(-4.584, 2.038)
Age 20–29yrs	0.009	0.531	-0.350	13.916
	(-0.553, 0.571)	(-0.195, 1.257)	(-1.034, 0.333)	(-6.282, 34.114)
Age 30–39yrs	-0.009	0.236	-0.173	9.634
	(-0.487, 0.470)	(-0.390, 0.862)	(-0.718, 0.373)	(-8.150, 27.419)
Age 40–49yrs	0.105	0.178	0.059	8.973
	(-0.502, 0.712)	(-0.525, 0.880)	(-0.646, 0.765)	(-7.653, 25.600)
Age 50–59yrs	-0.064	-0.112	-0.049	9.927
	(-0.552, 0.424)	(-0.716, 0.493)	(-0.545, 0.446)	(-5.704, 25.558)
Males	0.236	0.371	0.108	5.631
	(-0.152, 0.624)	(-0.186, 0.928)	(-0.410, 0.627)	(-7.885, 19.148)
Household size	-0.013	-0.232	-0.006	-0.271
	(-0.040, 0.014)	(-0.057, 0.011)	(-0.039, 0.027)	(-1.147, 0.604)
Divorced/separ./wid.	0.307	0.328	0.198	7.632
	(-0.129, 0.744)	(-0.197, 0.854)	(-0.356, 0.752)	(-1.406, 16.669)
Married/common law	0.222	0.249	0.183	5.532
	(-0.010, 0.455)	(-0.080, 0.578)	(-0.103, 0.469)	(-0.605, 11.670)
Family income‡	0.133	0.117	0.084	6.128
	(-0.215, 0.480)	(-0.346, 0.579)	(-0.344, 0.512)	(-2.989, 15.244)
Respondent income‡	-0.875*	-0.382	-0.961	-17.894
	(-1.734, -0.015)	(-1.665, 0.901)	(-2.021, 0.099)	(-38.960, 3.172)

Continued on next page

Table 4 – *Continued from previous page*

	Smoking participation	Occasional smoking	Daily smoking	Cigarettes per. day
Employed	0.045	-0.198	0.203	0.823
	(-0.144, 0.234)	(-0.459, 0.064)	(-0.004, 0.411)	(-4.115, 5.760)
Unemployed	-0.157	-0.088	-0.204	-6.270*
	(-0.472, 0.159)	(-0.430, 0.255)	(-0.550, 0.141)	(-11.582, -0.957)
Trad. language	0.097	0.259**	-0.039	-1.273
	(-0.021, 0.215)	(0.068, 0.451)	(-0.167, 0.089)	(-4.584, 2.038)
Attending school	-0.221	-0.534**	0.053	0.168
	(-0.453, 0.012)	(-0.876, -0.192)	(-0.278, 0.384)	(-6.521, 6.857)
High school grad.	-0.108	-0.060	-0.170	-1.547
	(-0.327, 0.111)	(-0.385, 0.266)	(-0.430, 0.089)	(-5.949, 2.854)
Com. problem index	0.132	0.021	0.199**	3.483*
	(-0.002, 0.265)	(-0.185, 0.226)	(0.045, 0.353)	(0.550, 6.416)
Observations	17,720	9,590	17,720	14,635
Adjusted R-squared	4.38%	4.29%	2.33%	3.43%

***,**,* Significant at the 1%, 5% and 10% level. 90% confidence intervals, based on robust standard errors adjusted for community level clustering, are reported in parenthesis. All regressions include community fixed effects and year effects. Family income is net of respondent's income. Cigarette prices reflect the point-of-sale price of 200 cigarettes for Status Indians purchasing on reserve. Nominal monetary variables are adjusted using the provincial consumer price index (2001 dollars.)
‡Income variables in 100,000 dollar values.

Table 5: Structural equation estimates

	Smoking participation	Occasional smoking	Daily smoking	Cigarettes per. day
log(Cigarette prices)	-0.079*	-0.142	-0.049**	-1.167*
	(-0.155, -0.003)	(-0.313, 0.029)	(-0.087, -0.011)	(-2.160, -0.173)
Community means				
Com. smoking rate†	0.474			
	(-0.075, 1.023)			
	{-0.405, 0.995}			
Com. smoking rate (occ.)†		-0.301		
		(-2.472, 1.869)		
		{-4.000, 1.020}		
Com. smoking rate (daily)†			0.785***	
			(0.555, 1.015)	
			{0.330, 0.965}	
Com. smoking intensity†				0.850***
				(0.458, 1.242)
				{0.250, 1.255}
SD of income‡	0.514	0.246	0.379**	5.187
	(-0.057, 1.085)	(-0.885, 1.377)	(0.085, 0.672)	(-3.510, 13.884)
Age $<$ 20yrs	0.225	1.270	-0.104	12.164**
	(-0.223, 0.672)	(-0.287, 2.826)	(-0.393, 0.184)	(2.750, 21.578)
Age 20–29yrs	-0.164	0.631***	-0.360	5.703
	(-0.580, 0.253)	(-0.601, 1.863)	(-0.580, -0.139)	(-2.630, 14.036)
Age 30–39yrs	-0.121	0.325	-0.192	3.583
	(-0.511, 0.269)	(-0.640, 1.290)	(-0.404, 0.021)	(-5.273, 12.438)
Age 40–49yrs	0.066	0.172	-0.034	3.548
	(-0.334, 0.467)	(-0.608, 0.951)	(-0.278, 0.210)	(-5.208, 12.304)
Age 50–59yrs	0.051	-0.077	0.113	6.422
	(-0.241, 0.342)	(-0.722, 0.567)	(-0.084, 0.310)	(-2.058, 14.903)
Males	0.080	0.416	-0.110	-2.008
	(-0.213, 0.373)	(-0.321, 1.154)	(-0.305, 0.084)	(-8.760, 4.745)
Household size	-0.013	-0.018	0.000	-0.125
	(-0.031, 0.005)	(-0.061, 0.024)	(-0.013, 0.013)	(-0.563, 0.313)
Divorced/separ./wid.	0.109	0.325	-0.011	3.450
	(-0.146, 0.364)	(-0.275, 0.926)	(-0.184, 0.161)	(-0.732, 7.632)
Married/common law	0.178	0.209	0.081	2.712
	(0.045, 0.310)	(-0.168, 0.586)	(-0.026, 0.188)	(-0.290, 5.713)
Family income‡	0.114	0.107	0.014	0.943
	(-0.137, 0.366)	(-0.448, 0.663)	(-0.163, 0.191)	(-4.789, 6.674)
Respondent income‡	-0.583	-0.307	-0.316	-2.521
	(-1.327, 0.160)	(-2.124, 1.511)	(-0.694, 0.061)	(-15.573, 10.532)
Employed	0.058	-0.256	0.095	-0.361
	(-0.050, 0.165)	(-0.822, 0.310)	(0.016, 0.173)	(-2.510, 1.788)
Unemployed	-0.086	-0.057	-0.040**	-3.099*
	(-0.272, 0.099)	(-0.411, 0.298)	(-0.148, 0.068)	(-5.958, -0.239)
Trad. language	0.052	0.301	0.006	1.619
	(-0.054, 0.158)	(-0.074, 0.677)	(-0.041, 0.054)	(-0.752, 3.990)
Attending school	-0.104	-0.588	0.044	-0.537
	(-0.278, 0.069)	(-1.247, 0.071)	(-0.069, 0.158)	(-3.721, 2.646)
First stage excluded				
High school grad.	-0.231*	0.088	-0.293*	
	(-0.450, -0.012)	(-0.170, 0.345)	(-0.551, -0.035)	
Com. problem index		-0.102	0.215**	4.096***
		(-0.239, 0.034)	(0.175, 0.254)	(1.666, 6.526)
Observations	17,220	9,220	17,220	17,220
First stage F-stat	3.00	1.22	5.36	7.69
First stage partial R^2	3.19	3.10	8.09	5.89
Hansen's J (p-value)	—	0.86	0.20	—

***,**,* Significant at the 1%, 5% and 10% level. 90% confidence intervals, based on robust standard errors adjusted for community level clustering, are reported in parenthesis. All regressions include community fixed effects and year effects. Family income is net of respondent's income. Cigarette prices reflect the point-of-sale price of 200 cigarettes for Status Indians purchasing on reserve. Nominal monetary variables are adjusted using the provincial consumer price index (2001 dollars.)
†90% CH bounds, robust to weak instruments, reported in braces.
‡Income variables in 100,000 dollar values.

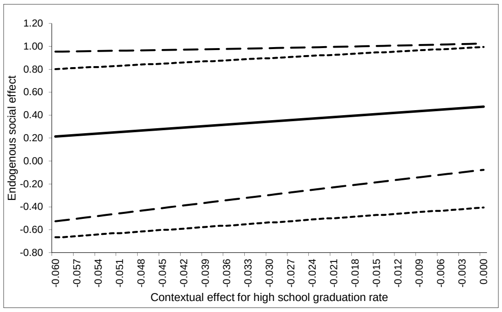
Table 6: Sensitivity analysis for structural equation estimates

	Smoking participation	Occasional smoking	Daily smoking	Cigarettes per. day
A				
log(Cigarette prices)	-.079*	-0.148	-0.048**	-1.122*
	(-0.155, -0.003)	(-0.327, 0.031)	(-0.085, -0.012)	(-2.094, -0.149)
Com. smoking†	0.484	-0.269	0.744***	0.871***
	(-0.007, 0.976)	(-2.468, 1.930)	(0.500, 0.987)	(0.449, 1.293)
	{-0.410, 0.969}	{-4.000, 1.080}	{0.090, 0.960}	{0.185, 1.335}
Com. obese	-0.032	0.171	-0.093*	-0.359
	(-0.160, 0.097)	(-0.198, 0.541)	(-0.177, -0.009)	(-2.727, 2.008)
Com. diabetes	0.365***	-0.531	0.224*	1.483
	(0.099, 0.632)	(-0.531, 0.655)	(0.023, 0.424)	(-6.663, 3.696)
First stage excluded				
High school grad.	-0.228*	0.094	-0.299*	—
	(-0.440, -0.016)	(-0.123, 0.311)	(-0.549, -0.0480)	
Com. problem index	—	-0.094	0.187*	3.884**
		(-0.207, 0.019)	(0.024, 0.350)	(1.326, 6.443)
Observations	17,220	9,220	17,220	17,220
First stage F-stat	3.12	1.18	4.53	6.24
First stage partial R^2	3.21	2.86	7.31	5.25
Hansen's J (p-value)	—	0.88	0.32	—
B				
log(Cigarette prices)	-0.055**	-0.073*	-0.032	-0.813
	(-0.093, -0.018)	(-0.137, -0.009)	(-0.066, 0.002)	(-1.796, 0.170)
Com. smoking†	0.425**	0.590	0.655***	0.676***
	(0.146, 0.704)	(-0.427, 1.608)	(0.370, 0.940)	(0.252, 1.010)
	{-0.020, 0.660}	{ -4.000, 1.360 }	{0.010, 0.860 }	{-0.120, 1.060 }
First stage excluded				
High school grad.	-0.359***	-0.056	-0.313**	—
	(-0.546, -0.171)	(-0.254, 0.142)	(-0.516, -0.109)	
Com. problem index	—	-0.117*	0.167*	3.925**
		(-0.232, -0.003)	(0.021, 0.314)	(1.416, 6.434)
Observations	17,220	9,220	17,220	17,220
First stage F-stat	9.90	1.71	5.04	6.62
First stage partial R^2	9.98	4.52	7.90	5.70
Hansen's J (p-value)	—	0.63	0.32	—
C				
log(Cigarette prices)	-0.073*	-0.120	-0.045*	-1.078*
	(-0.137, -0.009)	(-0.289, 0.050)	(-0.084, -0.007)	(-2.074, -0.083)
Com. smoking†	0.464**	-0.121	0.764***	0.783**
	(0.092, 0.837)	(-2.300, 2.058)	(0.529, 0.999)	(0.372, 1.193)
	{-0.360, 0.760}	{-4.000, 1.225}	{0.330, 0.920}	{0.015, 1.155}
First stage excluded				
High school grad.	-0.296**	0.060	-0.311**	—
	(-0.491, -0.101)	(-0.145, 0.265)	(-0.565, -0.056)	
Com. problem index	—	-0.-0.085	0.200**	4.096**
		(-0.189, 0.018)	(0.046, 0.355)	(1.505, 6.686)
Observations	17,220	9,220	17,220	17,220
First stage F-stat	6.23	1.04	5.97	7.77
First stage partial R^2	5.48	2.14	8.35	5.91
Hansen's J (p-value)	—	0.71	0.17	—

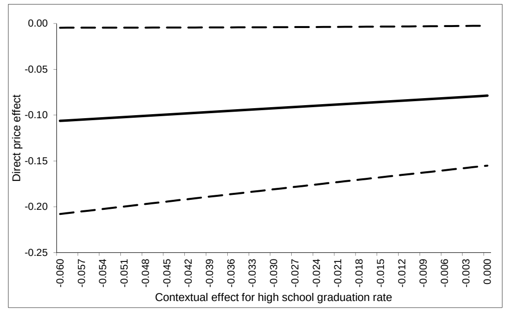
***,**,* Significant at the 1%, 5% and 10% level. 90% confidence intervals, based on robust standard errors adjusted for community level clustering, are reported in parenthesis. All regressions include

community fixed effects and year effects. Family income is net of respondent's income. Cigarette prices reflect the point-of-sale price of 200 cigarettes for Status Indians purchasing on reserve. Nominal monetary variables are adjusted using the provincial consumer price index (2001 dollars.)
Regressions include the following community means as *included* and *excluded* instruments:
A: (*included*) standard deviation of community income, age distribution, proportion males, household size, marital status, income, employment, speaks a traditional language, attending school, doctor diagnosed diabetes, obesity rate; (*excluded*) high school graduation, community problem index;
B: (*included*) standard deviation of community income, speaks a traditional language; (*excluded*) high school graduation, community problem index;
C: (*included*) standard deviation of community income, age distribution, marital status, employment (for occasional and daily only), speaks a traditional language, attending school; (*excluded*) high school graduation, community problem index.
†90% CH bounds, robust to weak instruments, reported in braces.

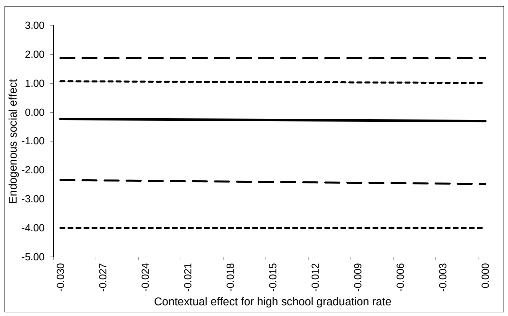
Figure 1: Sensitivity of the structural estimates test to relaxing the exclusion restrictions



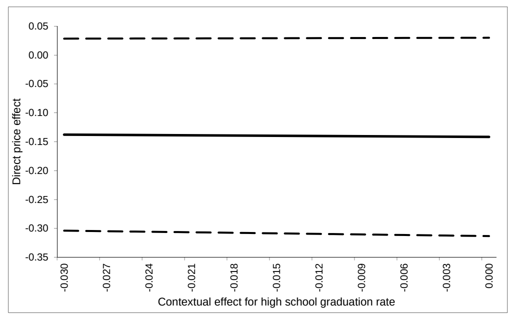
(a) Smoking participation: Endogenous social effects



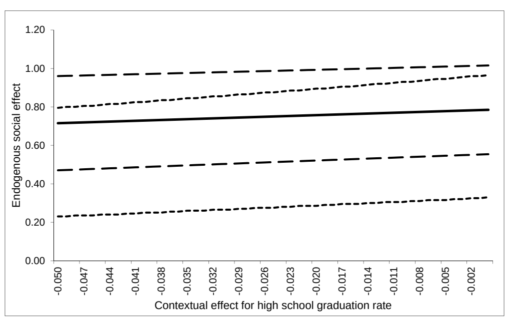
(b) Smoking participation: Direct price effect



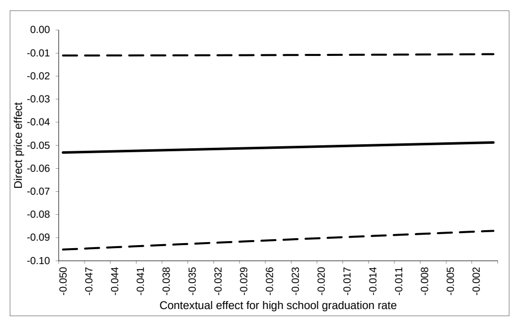
(c) Occasional smoking: Endogenous social effects



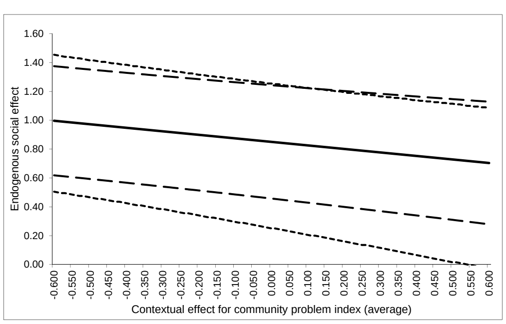
(d) Occasional smoking: Direct price effect



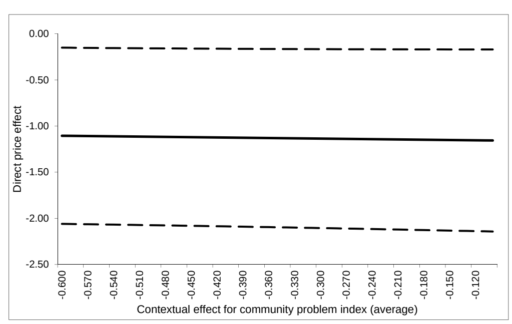
(e) Daily smoking: Endogenous social effects



(f) Daily smoking: Direct price effect



(g) Cigarettes per day: Endogenous social effects



(h) Cigarettes per day: Direct price effect

Horizontal axis includes values of θ_0 and vertical access includes corresponding estimates for α and η. Solid line represents point estimates, large dashed lines represent 90% robust asymptotic confidence intervals, small dashed line represents 90% CH bounds (minimum bound of -4).

Appendix: Communities included in analysis

Census Subdivision	Community Name	Province	Population (2001)	School	Health Center	Police	Recreation Center	Fire
1003801	Samiajij Miawpukek	NF	837	yes	yes	yes	yes	yes
1103035	Lennox Island 1	PEI	261	yes	yes	yes	yes	yes
1208014	Indian Brook 14	NS	932	yes	yes	yes	yes	yes
1210003	Millbrook 27	NS	821	yes	yes	yes	yes	yes
1217020	Eskasoni 3	NS	2741	yes	yes	yes	yes	yes
1310034	Devon 30	NB	692	yes	yes	no	yes	no
2499804	Mistissini	PQ	3125	no	no	no	no	no
2499806	Waskaganish	PQ	1699	no	yes	yes	no	no
2499814	Chisasibi	PQ	3467	no	no	yes	no	no
3543050	Mnjikaning F.N. 32	ON	597	yes	yes	yes	yes	no
3543069	Christian Island 30	ON	515	yes	yes	yes	yes	yes
3558003	Fort William 52	ON	599	no	yes	yes	yes	no
3559063	Couchiching 16A	ON	595	no	yes	yes	yes	yes
3560053	Fort Hope 64	ON	1001	yes	yes	yes	yes	yes
3560070	Deer Lake	ON	756	yes	yes	yes	no	no
3560071	Sandy Lake 88	ON	1704	yes	yes	yes	yes	yes
4606040	Sioux Valley 58	MB	1050	yes	yes	yes	yes	yes
4608069	Sandy Bay 5	MB	2446	yes	yes	yes	yes	yes
4616017	Waywayseecappo F.N.	MB	1135	yes	yes	yes	yes	yes
4617029	Ebb and Flow 52	MB	991	yes	yes	no	yes	yes
4618067	Fairford 50	MB	820	yes	yes	no	yes	yes
4619056	Fisher River 44	MB	867	yes	yes	no	yes	yes
4621029	Chemawawin 2	MB	964	yes	yes	yes	yes	yes
4621043	Opaskwayak Cree Nation 21E	MB	2025	yes	-	-	-	-
4622050	Oxford House 24	MB	1700	yes	yes	no	yes	yes
4622051	Cross Lake 19	MB	1491	yes	yes	no	yes	no
4622052	Cross Lake 19A	MB	502	-	-	-	-	-
4622058	Norway House 17	MB	3950	no	yes	yes	yes	yes
4622059	Nelson House 170	MB	1710	yes	yes	yes	yes	yes
4622063	Split Lake 171	MB	1581	yes	yes	no	yes	yes
4701808	White Bear 70	SK	536	yes	yes	yes	yes	yes
4705803	Cowessess 73	SK	486	yes	yes	yes	yes	yes
4706809	Piapot 75	SK	503	yes	yes	no	yes	no
4706810	Assiniboine 76	SK	646	yes	yes	yes	yes	yes
4706811	Standing Buffalo 78	SK	454	yes	yes	yes	no	yes
4706816	Peepeekisis 81	SK	396	yes	yes	no	yes	no
4710823	Gordon 86	SK	723	yes	yes	yes	yes	yes
4712830	Mosquito 109	SK	433	yes	yes	no	yes	no
4713835	Poundmaker 114	SK	505	yes	yes	yes	yes	yes

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Census Subdivision	Community Name	Province	Population (2001)	School	Health Center	Police	Recreation Center	Fire
4713836	Little Pine 116	SK	567	yes	yes	no	yes	yes
4715849	James Smith 100	SK	624	yes	yes	no	yes	yes
4715853	Montreal Lake 106B	SK	347	-	-	-	-	-
4716856	Sturgeon Lake 101	SK	873	yes	yes	yes	yes	yes
4716858	Big River 118	SK	1225	yes	yes	no	yes	yes
4716860	Ahtahkakoop 104	SK	1099	yes	yes	yes	yes	yes
4717801	Seekaskootch 119	SK	1834	yes	yes	yes	yes	yes
4717802	Makaoo (Part) 120	SK	175	-	-	-	-	-
4717805	Flying Dust F.N. 105	SK	575	yes	yes	yes	yes	no
4717806	Waterhen 130	SK	577	yes	yes	yes	yes	yes
4717807	Makwa Lake 129B	SK	736	-	-	-	-	-
4717809	Ministikwan 161	SK	573	yes	yes	no	yes	yes
4717812	Moosomin 112B	SK	514	yes	yes	yes	yes	yes
4718802	Montreal Lake 106	SK	861	yes	yes	yes	yes	yes
4718809	Lac La Ronge 156	SK	1181	-	-	-	-	-
4718812	Kitsakie 156B	SK	560	-	-	-	-	-
4718814	Wapachewunak 192D	SK	434	yes	yes	yes	yes	yes
4718817	Canoe Lake 165	SK	747	yes	yes	yes	yes	yes
4718818	Buffalo River Dene Nation 193	SK	607	yes	yes	yes	yes	yes
4718828	Chicken 224	SK	1075	yes	yes	yes	yes	yes
4718839	Clearwater River	SK	548	yes	yes	no	yes	yes
4803801	Peigan 147	AB	-	yes	yes	no	yes	yes
4803802	Blood 148	AB	3852	yes	yes	yes	yes	yes
4805802	Siksika 146	AB	2750	yes	yes	yes	yes	yes
4806804	Tsuu T'ina Nation 145	AB	-	-	-	-	-	-
4810805	Makaoo (Part) 120	AB	175	-	-	-	-	-
4811803	Louis Bull 138B	AB	892	yes	yes	yes	yes	yes
4811804	Stony Plain 135	AB	1100	yes	yes	no	yes	yes
4815802	Stoney 142, 143, 144	AB	2173	yes	yes	no	yes	yes
4817819	Wabasca 166A	AB	510	-	-	-	-	-
4817823	Wabasca 166D	AB	860	yes	no	no	no	no
4817824	Utikoomak Lake 155	AB	812	yes	yes	yes	no	yes
4817837	John d'Or Prairie 215	AB	851	-	-	-	-	-
5909832	Seabird Island	BC	535	yes	yes	no	yes	yes
5909839	Chehalis 5	BC	460	yes	yes	no	no	yes
5915803	Musqueam 2	BC	1305	yes	yes	no	yes	no
5915807	Mission 1	BC	550	no	no	no	yes	no
5915808	Capilano 5	BC	2230	-	-	-	-	-
5919804	Chemainus 13	BC	557	yes	yes	no	yes	no
5919807	Cowichan 1	BC	1201	yes	yes	no	yes	no
5923816	Tsahaheh 1	BC	322	yes	yes	no	yes	no
5929803	Sechelt (Part)	BC	-	no	yes	no	no	no
5933880	Kamloops 1	BC	1410	yes	yes	yes	yes	no
5937801	Okanagan (Part) 1	BC	95	no	yes	no	yes	yes
5941801	Alkali Lake 1	BC	396	yes	yes	yes	yes	yes
5941812	Williams Lake 1	BC	273	no	yes	no	yes	yes
5943801	Alert Bay 1	BC	281	-	-	-	-	-
5943802	Alert Bay 1A	BC	411	yes	yes	no	yes	no
5943806	Tsulquate 4	BC	387	no	no	yes	no	no
5949803	Kitamaat 2	BC	511	yes	yes	yes	yes	yes
5949811	Hagwilget 1	BC	237	no	yes	no	yes	yes
5949812	Gitanmaax 1	BC	693	yes	yes	no	yes	yes
5949814	Gitsegukla 1	BC	432	yes	yes	no	yes	yes
5949816	Gitwangak 1	BC	475	yes	yes	no	yes	yes
5955801	East Moberly Lake 169	BC	330	yes	yes	no	no	no
5959806	Fort Nelson 2	BC	390	yes	yes	yes	yes	no

Community facility information and population sizes found at *Aboriginal Canada Portal*: `http://www.aboriginalcanada.gc.ca/acp/site.nsf/eng/index.html`. F.N. stands for First Nation.